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Global warming – more on bio-fuels

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Global warming – more on bio-fuels

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(Fifth in a Series)

In the previous article we discussed the greenhouse gas emissions from corn and biomass (cellulosic) ethanol. If only the “direct” effects of producing ethanol on existing cropland are considered, ethanol produces fewer greenhouse gas emissions than gasoline. In this article we will examine the controversy over the “indirect land use” effects of using existing cropland for ethanol production. We will also examine the emissions from converting native ecosystems to ethanol production.

The world’s demand for food and feed and the world’s agricultural capacity to produce food and feed are roughly in balance. If large areas of agriculture’s production capacity are switched from food production to fuel production, either food shortages will arise or agriculture’s production capacity must expand. Production capacity can expand in two ways – through increased yields per acre or more acres. Although increasing yields is a powerful way to expand production, it tends to occur gradually over time. Agriculture’s production will expand more rapidly by increasing the land area under cultivation.

Native ecosystems

As the global ethanol industry expands, it is likely that native soils and ecosystems will be converted to farmland for bio-fuel production. In some parts of the world this process has already started. Estimates have been made of the impact on greenhouse gas emissions of producing ethanol on native ecosystems in different parts of the world. Three examples are shown in Table 1.

The carbon “debt” shows the soil carbon emissions created by transforming virgin land into bio-fuel production (the carbon emissions from this process were discussed in the previous article). Next, the

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For those of you subscribing to the handbook, the following updates are included.

Monthly Swine Farrow to Finish Returns – B1-31 (2 pages)

Monthly Returns from Finishing Feeder Pigs – B1-34 (1 page)

Monthly Cattle Feeding Returns – B1-36 (2 pages)

Historic Hog and Lamb Prices – B2-10 (4 pages)

Historic Cattle Prices – B2-12 (4 pages)

Lean Hog Basis – B2-41 (1 page)

Feeder Cattle Basis – B2-43 (1 page)

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Inside . . .

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percent of emissions "allocated to bio-fuels" represents the portion of the production that goes to bio-fuel production. For example, 39 percent of Brazilian soybean production is allocated to the oil used for bio-diesel production with the remainder allocated to soybean meal. The "annual repayment" represents the annual reduction in equivalent CO^2 emissions from using bio-fuels rather than gasoline to repay the carbon debt. The "repayment period" is the number of years required for the annual payment to repay the carbon debt.

For example, it will take 86 years of "annual payments" from palm biodiesel production to repay the "carbon debt" from converting tropical rainforest to palm biodiesel production. Only after the year 2094 (2008 + 86 = 2094) will the cumulative emissions from palm biodiesel production be less than those of gasoline.

Converting central US grasslands to corn ethanol production will require almost 100 years to repay the carbon debt (emissions) from converting grassland to corn production. Converting Brazilian grasslands to biodiesel production will require 37 years.

According to the calculations by Fargione et al., unless a way can be found of maintaining soil carbon, converting native ecosystems to bio-fuels production as a replacement for gasoline will not reduce greenhouse gas emissions.

Indirect emissions

It appears that, in general, bio-fuels produced on existing US farmland (discussed in our previous article) produces fewer emissions than gasoline while bio-fuels produced on converted land (Table 1) produces more greenhouse gas emissions.

However, the picture is somewhat more complex. Recent scientific research has focused on the indirect change in land use from using corn for energy instead of food. Changing land use from feed/food to fuel in one location may trigger a change in land use to feed/food in another location. For example, what is the indirect effect of converting an acre of Midwest from corn for feed and food production to corn for ethanol production?

Transitioning this acre of Midwest cropland may mean that somewhere in the world an acre of virgin land is converted to farmland for feed and food production to make up for the lost acre in the Midwest. Market prices are the mechanism causing this transition. Reducing the feed supply will raise feed prices which will provide an incentive to increase feed production somewhere else.

Table 2 shows the "indirect land use" changes from using farmland for fuel production rather than feed production. This change in land use triggers substantial greenhouse gas emissions. Table 2 is the same chart as shown in the previous article except that the indirect effect of carbon emissions from land use change is taken into effect. By including land use changes, corn ethanol produces 93 percent more emission than gasoline. Cellulosic ethanol produces 50 percent more.

The production of 15 billion gallons of ethanol (the current mandate for corn-starch ethanol) will cause a large shift in corn acres from feed production to energy production. This conversion from feed production to fuel production could trigger a large acreage shift of virgin land into farmland for feed production in other parts of the world.

Table 1. Greenhouse gas emissions for selected examples of bio-fuels production

	Palm Biodiesel in Indonesia/Malaysia (Tropical Rainforest)	Soy Biodiesel in Brazil (Cerrado Grassland)	Corn Ethanol in Central U.S. (Grassland)
Carbon Debt 1/	702	85	134
Allocated to Bio-fuels (%) 2/	87	39	83
Annual Repayment 3/	7.1	0.9	1.2
Repayment Period (yrs) 4/	86	37	93

1/ Carbon debt, including CO^2 emissions from soils and aboveground and belowground biomass due to habitat conversion (Mg CO^2 ha-1)

2/ Proportion of total carbon debt allocated to biofuel production

3/ Annual life-cycle GHG reduction from bio-fuels, including displaced fossil fuels and soil carbon storage (Mg CO^2eha-1 yr-1)

4/ Number of years after conversion to biofuel production required for cumulative biofuel GHG reductions, relative to fossil fuels they displace, to repay the biofuel carbon debt.

Source: Fargione, et al. (2008)

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Table 2. Gasoline and ethanol greenhouse gas (GHG) emissions considering land use changes (grams of GHGs CO² eq. per MJ of energy in fuel)

Fuel Source	Making Feedstock	Refining Fuel	Vehicle Operation	Feedstock Uptake	*Land Use Change*	Total GHGs	Percent Change
Gasoline	+4	+15	+72	0	--	+92	--
Corn Ethanol	+24	+40	+71	-62	***+104***	+177	+93
Biomass Ethanol	+10	+40	+71	-62	***+111***	+138	+50

Source: Searchinger, et al. (2008)

Not so fast

While the logic used in the scenario above seems reasonable, other scientists raise questions about the underlying assumptions used to obtain these results. The analysis provides one scenario of what might happen, but this is not the only one. Other scientists have questioned whether global markets for agricultural commodities are as tightly coupled as is assumed in the previous analysis. And enhanced yields on both existing high-yielding land and marginally producing land need to be considered, as do biofuel sources other than food/feed grains. Further research is needed to assess to what extent a change of the proposed magnitude in one part of the world will trigger the projected response in another part of the world. The conversion of native ecosystems to agricultural production started well before the emergence of the bio-fuels demand.

Implications

Research to assess the indirect impact of converting agricultural production from food/feed production to fuel production is just beginning. Additional research is forthcoming to improve our understanding of this relationship and its impact. However, measuring the carbon loss from the conversion of the myriad of different types of ecosystems around the world is daunting.

The implementation of a world-wide carbon tax or cap-and-trade system, along with good data on carbon loss and gain under different land-use scenarios, will help balance the cost of carbon emissions with the need for food and fuel. Although this may seem like a distant goal, it does provide the framework for a viable solution.

As discussed in the previous articles, efforts to curb greenhouse gas emissions will impact the world our children and grandchildren will inherit. However, in the short term (present time to 2030), we will have little impact on global warming and will need to adapt to the climate changes that are coming. The next article will focus on how global warming may impact the production capacity of Midwest agriculture.

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